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State of Washington

Final Cost-Benefit and Least Burdensome Alternative Analyses

Chapter 173-183 WAC
Oil Spill Natural Resource Damage Assessment

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for the

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Executive Summary

The Department of Ecology (Ecology) is amending Chapter 173-183 WAC – Oil Spill Natural Resource Damage Assessment (NRDA). The Administrative Procedures Act (RCW 34.05.328(1)(d)(e)) requires two types of analyses before adopting a significant legislative rule – a cost-benefit analysis and a least burdensome alternative analysis. This report provides the results of these analyses and shows the potential impacts associated with the adopted rule. The rule amendments include changes:

- To the current compensation schedule such that the amount of compensation is between
  - $1 and $100 per gallon of oil spilled when the spill is less than 1,000 gallons.
  - $3 and $300 per gallon of oil spilled when the spill is equal to or more than 1,000 gallons.
- Such that the monetary damage liability is consistent with changes in house bill (HB) 1186.
- To address how recovery credits are provided for "persistent" oil, also required by HB 1186.
- Such that Ecology deducts the volume of persistent oil recovered in 48 hours from the total spill volume when determining compensation amounts.

Table 1 shows the expected costs to the people of the state of Washington over 20 years, discounted at an annual rate of 1.58 percent.[1] The estimates for "Low" and "High" correspond to the damages a potentially liable party (PLP) might pay depending on where the spill occurred, as explained in the analysis. The previous NRDA rule and the state Resource Damage Assessment (RDA) committee guidelines correspond to the two different baselines (NRDA and RDA), as explained in Chapter 2: Baseline for Analysis.

Table 1: Costs

Costs (NRDA)	Low	High
Forgone restoration (shorelines)	$589,957.51	$4,675,300.32
Forgone restoration (open water)	$19,216.77	$128,347.84
Costs (RDA)		
Increased damages paid by liable parties	$62,638.00	$322,503.15
Costs (both baselines)		
Required testing (oil in water, oil in debris)	$51,371.01	$51,371.01
Required testing (specific gravity)	$569.30	$569.30
NRDA total costs	$661,114.59	$4,855,588.47

[1] Ecology uses a discount rate based on interest that could be earned risk-free on today's dollars over the relevant time period. Ecology uses the ten-year average rate of return offered on the US Treasury's T-Bills (inflation-indexed short-term bonds; US Treasury Department, 2012) as the discount rate, averaging 1.58 percent over the last ten years.

RDA total costs	$114,578.31	$374,443.46

Table 2 shows the expected benefits to the people of the state of Washington over 20 years, discounted at an annual rate of 1.58 percent.

Table 2: Benefits

Benefits (NRDA)	Low	High
Decreased damages paid by liable parties	$963,140.74	$7,006,681.10
Benefits (RDA)		
Increased restoration (shorelines)	$80,116.88	$412,495.68
NRDA total benefits	$963,140.74	$7,006,681.10
RDA total benefits	$80,116.88	$412,495.68

Chapter 1: Background and Scope

1.1 Background

When an oil spill injures Washington's publicly-owned natural resources (e.g., fish, birds, beaches, parks, water quality, recreational sites), the spiller is liable. This includes the cost of restoring public resources to pre-spill levels and for compensating the public for those resources lost while the restoration takes place. The state quantifies these injuries through the NRDA process and scales them to restoration efforts of equal value. The value, expressed as a dollar amount, is called "damages". To determine damages, Washington uses a compensation schedule based on natural resource vulnerability, oil type, and volume of oil spilled. Damages collected through the state process are deposited into a state account funding high priority public restoration projects.

1.1.1 History of existing rule

The U.S. Oil Pollution Act of 1990 established a federal process for assessing damages to federal resources based on the analysis of the pathway, exposure, and injury of public resources. The federal process often includes completing a Habitat Equivalency Analysis to help scale the restoration to the determined injury. This process is put in place through an incident-specific agreement regarding what to study, how to collect data, and where restoration takes place. Combined with settlement negotiations, this process can be time consuming and costly. The federal process is typically only used once a year in Washington – and then only on major oil spills.

State NRDA laws and rules establish a different process. Washington uses a simpler, more easy-to-understand compensation schedule based on natural resource vulnerability, oil type, and volume of oil spilled. Damages collected through the state process are deposited into a state account funding high priority public restoration projects. Spillers who quickly remove spilled oil from the water are eligible to receive credit for the amount of oil they clean up. This “recovery credit” recognizes the ecological benefits of early oil recovery and provides an incentive for spillers to take immediate action when they have a spill.

The state RDA committee decides which NRDA process is appropriate. In general, smaller spills run through the state process while the larger spills run through the federal process. The selection of assessment method is made during a public preassessment screening process by the RDA Committee representing the:

- Department of Ecology.
- Department of Fish and Wildlife.
- Department of Natural Resources.
- Department of Health.
- Department of Archeology and Historic Preservation.
- Washington State Parks and Recreation Commission.

Tribal and local government representatives may also be invited to join the process to streamline decision making. Spillers (companies and/or individuals) are also invited to provide input for the decisions made by the RDA Committee.

1.1.2 Reason for the rule adoption

In 2011 the Washington State Legislature passed House Bill (HB) 1186 and the bill was codified in state law (Chapter 90.48 RCW). The legislation requires Ecology to amend its current compensation schedule. Under the new law, the amount of compensation assessed for spills is between:

- $1 and $100 per gallon of oil spilled when the spill is less than 1,000 gallons.
- $3 and $300 per gallon of oil spilled when the spill is equal to or more than 1,000 gallons.

The legislation also requires Ecology to deduct the volume of persistent oil recovered in 48 hours from the total spill volume when determining compensation amounts. The historical “recovery credit” process has been implemented through guidance promulgated in 1996 by the RDA Committee. This guidance needs to be moved into rule.

Ecology’s rule language achieves two things:

- Makes the monetary damage liability consistent with changes in HB 1186.
- Addresses how recovery credits are provided for “persistent” oil, also required by HB 1186.

1.2 Scope of analysis

Ecology analyzes the impacts of Ecology’s adopted rule in the following sections:

- **Chapter 2: Baseline for Analysis**
  Explains the baseline concepts to which Ecology’s adopted rule was compared in the analysis, and analyzes the rule impacts.

- **Chapter 3: Historical Spills Data**

Summarizes the data used in the analysis of the costs and benefits of the adopted rule, and the parameter estimates obtained from that data.

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- **Chapter 4: Costs of Adopted** Rule
  Explains the costs of the rule amendments.

- **Chapter 5: Benefits of Adopted Rule**
  Explains the benefits of the rule amendments.

- **Chapter 6: Conclusion**
  Summarizes Ecology's results and includes comments on the analysis.

- **Chapter 7: Least Burdensome Alternative Analysis**
  Explains Ecology's determination on whether the adopted rule places the least burden possible on those required to comply with it, while fulfilling the goals and objectives of the authorizing legislation.

Chapter 2: Baseline for Analysis

2.1 Introduction

Ecology describes the baseline to which the rule amendments are compared. The baseline is the regulatory context in the absence of the amendments being adopted.

Ecology also describes the rule amendments, Administrative Procedure Act (Chapter 34.05 the scope of the analysis, and indicates which cost and benefit analyses are discussed in Chapters Chapter 3: Historical Spills Data and

Chapter 4: Costs of Adopted Rule.

2.2 Baseline

The baseline is the regulatory context in the absence of the amendments being adopted. In most cases, the regulatory baseline is the existing rule. The baseline also includes existing federal, state, or local government regulations, as well as the statute authorizing the rule. Even in the absence of the adopted rule, liable parties are required to comply with other existing regulations. As such, this cost-benefit analysis only estimates the additional costs and benefits resulting from the adopted rule in excess of those in existing federal, state, or local government regulations, including the statute authorizing the rule.

The baseline for the rule amendments to the NRDA rule is complex. There are multiple factors involved. These factors are:

- The existing NRDA rule (Chapter 173-183 WAC).

- The statute authorizing the NRDA rule (Chapter 90.48 RCW), as amended by HB 1186 in 2011. There exist specific changes to the NRDA rule mandated by statute, which are not analyzed in the cost-benefit per RCW 34.05.328(5)(b)(v).
- The state RDA committee guidelines for reducing compensation amounts due to the early recovery action of the spiller (recovery credit). These guidelines have been used in Washington State since 1996, and are different from the existing NRDA rule.

Below, Ecology shows which changes are explicitly determined in statute. The changes Ecology does not have discretion over are not analyzed. For the changes Ecology does have discretion over, we compare to two baselines, the existing NRDA rule and the state RDA guidelines. The RDA guidelines are the most practical comparison containing the compensation schedule most closely followed in Washington State since 1996.[2] They are also not the legal baseline however, as the RDA guidelines are not the existing rule. The existing NRDA rule compensation schedule has not been in practical use. Ecology compares the adopted rule to both baselines in order to provide the most reliable information to the public, but the legal comparison and determining factor is the existing NRDA rule. The comparison to the RDA guideline is meant to be informative.

2.3 Changes under Ecology's adopted rule

Ecology qualitatively or quantitatively analyzed the impacts of the following changes to the NRDA rule. We also identify if the change was not analyzed (for example if it was mandated by statute). We refer to two baselines in our analysis – the existing NRDA rule, and the RDA guidelines.

2.3.1 Compensation schedule

Certain changes to the compensation schedule were analyzed below.

We do not analyze the increase in damages to \$3-\$300 per gallon for spills greater than or equal to 1,000 gallons – the change to the multiplier "x". The statute requires the amount of compensation assessed for spills totaling 1,000 gallons or more must be between \$3 and \$300 per gallon of oil spilled (as opposed to \$1-\$100 before). The "x" multiplier found in the compensation schedules for spills greater than or equal to 1,000 gallons has thus been updated so damages will always lie between \$3 and \$300 per gallon of oil spilled – the "x" has simply been multiplied by three. This change is mandated in statute, and therefore has not been analyzed.

We also do not analyze the change allowing 48 hours for recovery of persistent oils. This change is also mandated in statute.

There are four different schedules for oil spills:

- Marine and estuarine waters.

[2] The RDA guidelines are, as their name suggests, guidance, and in recent years has incorporated aspects of the adopted rule (such as when data limitations prevented calculation of the compensation schedule). As a result, the changes from either baseline estimated in this analysis are likely overestimates because in practice some changes have already been in use.

- The Columbia River estuary.
- Freshwater streams, rivers, and lakes.
- Freshwater wetlands.

All schedules establish the relative vulnerability of publicly-owned resources by taking into consideration their sensitivity (formalized in the "SVS" coefficient), and consider the following characteristics of the spilled oil (formalized in the "OIL" coefficient):

- Acute (immediate) toxicity – Amount of volatile, potentially toxic compounds in the oil that readily dissolve into water and are capable of killing plants and animals by poisoning. Inhalation of volatile compounds may also kill by poisoning.
- Mechanical injury – How much harm the oil causes to organisms and habitats due to its physical impact (coating, smother).
- Persistence – How long the oil will stay in the environment before it breaks down.

Spillers who quickly remove spilled oil from the water are eligible to receive credit for the amount of oil they clean up. This "recovery credit" is based on the ecological benefits of early oil recovery and additionally it provides an incentive for spillers to take immediate action when they have a spill. In subsequent sections, "containment" means the liable party has placed a boom around the spill and the oil is inside a primary containment boom. Generally, a boom around the spill has historically met the criteria of "contained" in previous spill assessments. There have been cases however where boom was deployed but due to weather, current, or deployment errors, the oil escaped.

Adopted Rule

For spills of non-persistent oils when there is both effective containment and no shoreline contact, the gallons recovered within 24 hours are subtracted from the gallons spilled in the mechanical injury (MI) and persistent effects (PER) parts of the formulas, or:

$$Damages(\$)_{Prop\_a} = x * \left[(OIL_{AT} * SVS_{AT} * gallons\ spilled) + \left(OIL_{MI} * SVS_{MI} * (gallons\ spilled - gallons\ recovered\ in\ 24\ hours) \right) + \left(OIL_{PER} * SVS_{PER} * (gallons\ spilled - gallons\ recovered\ in\ 24\ hours) \right) \right].$$

For spills of non-persistent oils when there is a failure of containment and/or there is shoreline contact, the gallons recovered within 24 hours are subtracted from the gallons spilled in only the PER part of the formulas, or:

$$Damages(\$)_{Prop\_b} = x * \left[(OIL_{AT} * SVS_{AT} * gallons\ spilled) + (OIL_{MI} * SVS_{MI} * gallons\ spilled) + \left(OIL_{PER} * SVS_{PER} * (gallons\ spilled - gallons\ recovered\ in\ 24\ hours) \right) \right].$$

For spills of persistent oils when there both effective containment and no shoreline contact, the gallons recovered within 48 hours are subtracted from the gallons spilled in the MI and PER parts of the formulas, or:

$$Damages(\$)_{Prop\_c} = x * \left[(OIL_{AT} * SVS_{AT} * gallons\ spilled) + \left(OIL_{MI} * SVS_{MI} * (gallons\ spilled - gallons\ recovered\ in\ 48\ hours) \right) + \left(OIL_{PER} * SVS_{PER} * (gallons\ spilled - gallons\ recovered\ in\ 48\ hours) \right) \right].$$

For spills of persistent oils when there is a failure of containment and/or there is shoreline contact, the gallons recovered within 48 hours are subtracted from the gallons spilled in only the PER part of the formulas, or:

$Damages(\$)_{Prop\_d} = x * [(OIL_{AT} * SVS_{AT} * gallons\ spilled) + (OIL_{MI} * SVS_{MI} * gallons\ spilled) + (OIL_{PER} * SVS_{PER} * gallons\ spilled - gallons\ recovered\ in\ 48\ hours))].$

NRDA Baseline

For spills of non-persistent and persistent oils when there is no shoreline contact and the water depth is greater than twenty meters, 10 percent of the gallons recovered "immediately" are subtracted from the gallons spilled in the MI and PER parts of the formulas, or:

$Damages(\$)_{NRDA\_a} = x * \left[(OIL_{AT} * SVS_{AT} * gallons\ spilled) + \left(OIL_{MI} * SVS_{MI} * \right.\right.$ *gallons spilled−0.1∗gallons recovered immediately+OILPER∗SVSPER∗gallons spilled−0.1∗gallons recovered immediately.*

When there is shoreline contact and/or the water depth is less than twenty meters, there is no recovery credit, or:

$Damages(\$)_{NRDA\_b} = x * [(OIL_{AT} * SVS_{AT} * gallons\ spilled) + (OIL_{MI} * SVS_{MI} *$ *gallons spilled+OILPER∗SVSPER∗gallons spilled.*

RDA Baseline

The compensation schedule for the RDA baseline can be found in RDA Committee Resolution 96-1.1.[3] The intent of the recovery credit reflects the RDA Committee's recognition that early containment and recovery of oil from the environment directly reduces the expected natural resource injuries caused by a spill. The credit reflects the direct avoidance of persistence effects and the likely reduction in mechanical effects when oil is contained and recovered. If oil is not contained, then the likely reduction in mechanical injury effects cannot be assured.

When the spilled oil is contained within 1,000 feet of the spill source or the point where the oil first enters state waters (spills of non-persistent and persistent oils), the gallons recovered within 24 hours are subtracted from the gallons spilled in the MI and PER parts of the formulas, or:

$Damages(\$)_{RDA\_a} = x * \left[(OIL_{AT} * SVS_{AT} * gallons\ spilled) + \left(OIL_{MI} * SVS_{MI} * \right.\right.$ *gallons spilled−gallons recovered in 24 hours+OILPER∗SVSPER∗gallons spilled−gallons recovered in 24 hours,*

When a portion of the oil is contained, but some is also recovered from outside containment or exceeds the 1,000 feet from the spill source or the point where the oil first enters state waters (spills of non-persistent and persistent oils), the gallons recovered inside containment, in 24 hours, are subtracted from the gallons spilled in only the MI

[3] Current Oil Recovery Credit Form

part of the formula. The total gallons of oil recovered both within and outside the 1,000 feet radius is subtracted from the PER part of the formula, or:

$$Damages(\$)_{RDA\_b} = x * \left[(OIL_{AT} * SVS_{AT} * gallons\ spilled) + \left(OIL_{MI} * SVS_{MI} * (gallons\ spilled - gallons\ \ recovered\ within\ containment\ and\ 1{,}000\ feet\ in\ 24\ hours)\right) + \left(OIL_{PER} * SVS_{PER} * (gallons\ spilled - all\ gallons\ recovered\ in\ 24\ hours)\right)\right],$$

$$such\ that\ (all\ gallons\ recovered\ in\ 24\ hours) = (gallons\ recovered\ within\ containment\ and\ 1{,}000\ feet\ in\ 24\ hours) + (gallons\ recovered\ outside\ of\ 1{,}000\ feet\ in\ 24\ hours).$$

When oil is not contained, the spiller receives recovery credit for total gallons of oil recovered within 24 hours for the PER part of the formula. The spiller receives no credit for the MI part of the formula. This is because oil is contained when it is inside a containment boom. When oil is not contained spillers receive credit in the MI part of the formula for the “primary recovery volume” only, which is defined as recovery inside 1,000 feet and inside the primary containment boom, which must equal zero by definition (if the oil was inside the primary containment boom, it would be contained). Damages equal:

$$Damages(\$)_{RDA\_c} = x * \left[(OIL_{AT} * SVS_{AT} * gallons\ spilled) + (OIL_{MI} * SVS_{MI} * gallons\ spilled) + \left(OIL_{PER} * SVS_{PER} * (gallons\ spilled - gallons\ recovered\ in\ 24\ hours)\right)\right].$$

Changes from NRDA Baseline

There is no change in timing analyzed. In program experience the term “immediately” historically means 24 hours in practical use. Therefore there is no change in timing from the baseline for non-persistent oils. The change to 48 hours for persistent oils is mandated by statute. For comparison purposes, this is algebraically identical to allowing “gallons recovered in 24 hours” to equal “gallons recovered in 48 hours”. When this is the case, $Damages(\$)_{Prop\_a} = Damages(\$)_{Prop\_c}$ and $Damages(\$)_{Prop\_b} = Damages(\$)_{Prop\_d}$. The respective damage equations for persistent and non-persistent oils when there is shoreline contact and no shoreline contact are identical.

There is a change in recovery credit. The liable party receives 100 percent of the credit for both MI and PER under the adopted rule, when there is no shoreline contact and there is effective containment. Under the NRDA baseline they only receive 10 percent.

We do not analyze the requirement under the NRDA baseline that water depth be greater than 20 meters for recovery credit. It is difficult for on-scene coordinators (OSCs) to determine visually if the depth is greater or less than 20 meters. We do not keep track of this data and this is also one reason why this schedule is not in practical use. We therefore assume all spills are in water with depth greater than 20 meters. This assumption may result in an overestimation of recovery credit under the NRDA baseline. This means when we analyze the change from the NRDA baseline to the adopted rule the additional recovery credit granted by the adopted rule may be underestimated (because we assume the upper bound of recovery credit under the baseline and the more recovery credit under the baseline, the smaller the difference to the adopted rule).

Letting "gallons recovered immediately" equal "gallons recovered in 48 hours" equal "gallons recovered in 24 hours", respectively, for the reasons explained above (the change to 48 hours is mandated by statute; historically "immediately" means 24 hours in practical use), the difference in damages is equal to:

$$Damages(\$)_{Prop\_a} - Damages(\$)_{NRDA\_a} = Damages(\$)_{Prop\_c} - Damages(\$)_{NRDA\_a} = -x * 0.9 * [(OIL_{MI} * SVS_{MI} * gallons\ recovered\ in\ 24\ hours) + (OIL_{PER} * SVS_{PER} * gallons\ recovered\ in\ 24\ hours)].$$

We note the identity is negative – the damages under the adopted rule are smaller.

Also, liable parties receive 100 percent of the credit for PER when there is shoreline contact and effective containment. They receive no credit under the NRDA baseline with shoreline contact. The difference in damages is equal to:

$$Damages(\$)_{Prop\_b} - Damages(\$)_{NRDA\_b} = Damages(\$)_{Prop\_d} - Damages(\$)_{NRDA\_b} = -x * [(OIL_{PER} * SVS_{PER} * gallons\ recovered\ in\ 24\ hours)].$$

We note the identity is negative – the damages under the adopted rule are smaller.

Changes from RDA Baseline

As explained above, the changes allowing 48 hours of recovery for persistent oils is mandated in statute. Therefore the change is not analyzed, and for comparison purposes "gallons recovered in 24 hours" equals "gallons recovered in 48 hours". When this is the case, $Damages(\$)_{Prop\_a} = Damages(\$)_{Prop\_c}$ and $Damages(\$)_{Prop\_b} = Damages(\$)_{Prop\_d}$. The respective damage equations for persistent and non-persistent oils when there is shoreline contact and no shoreline contact are identical.

With no containment, the adopted rule and the RDA baseline are identical – the damages are equal to $Damages(\$)_{Prop\_b} = Damages(\$)_{RDA\_c}$.

When there is containment and no shoreline contact and the spill is contained within a 1,000 feet radius from the origin of the spill, there is no change from the RDA baseline to the adopted rule. The damages are equal to $Damages(\$)_{Prop\_a} = Damages(\$)_{RDA\_a}$.

When there is containment and no shoreline contact and the spill is not contained within the 1,000 feet radius, the RDA baseline allows for credit of oil recovered outside the radius, but only for PER. While both the RDA baseline and the adopted rule require the spill be contained, the adopted rule allows credit for MI and PER, regardless of the distance to the origin of the spill. Therefore, damages are greater under the RDA baseline, and the difference equals:

$$Damages(\$)_{Prop\_a} - Damages(\$)_{RDA\_b} = -x\big[\big(OIL_{MI} * SVS_{MI} *$$

$(gallons\ recovered\ in\ 24\ hours -$
$gallons\ recovered\ within\ 1{,}000\ feet\ in\ 24\ hours))\big]$.
The difference in damages depends on the proportion of oil outside of the 1,000 feet radius.

When there is containment and the spill is within 1,000 feet of the origin and there is shoreline contact, damages equal $Damages(\$)_{RDA\_a}$ under the RDA baseline and $Damages(\$)_{Prop\_b}$ under the adopted rule. The difference equals:
$Damages(\$)_{Prop\_b} - Damages(\$)_{RDA\_a} =$
$x * \big[\big(OIL_{MI} * SVS_{MI} * (gallons\ recovered\ in\ 24\ hours)\big)\big]$.
Under the RDA baseline a liable party can contain the spill within 1,000 feet of the origin of the spill, have the spill touching the shoreline, and still receive full credit (both PER and MI) for oil recovered within 24 hours. Under the adopted rule, any shoreline contact means the liable party receives credit for PER only. The damages are greater under the adopted rule.

It is also possible to have containment, shoreline contact, and have the spill outside the 1,000 feet radius. If so, there are greater damages under the adopted rule, or:
$Damages(\$)_{Prop\_b} - Damages(\$)_{RDA\_b} =$
$x * \big[\big(OIL_{MI} * SVS_{MI} * (gallons\ recovered\ within\ 1{,}000\ feet\ in\ 24\ hours)\big)\big]$.

2.3.2 Definition of "persistent"

We do not analyze this change.

"Persistent" oil is not defined in either the RDA or NRDA baseline. It is defined in the adopted rule. We do not analyze this change as the definition in the adopted rule is taken verbatim from U.S. Coast Guard 33 CFR 154 and 155 and EPA 40 CFR 112.20 and 112.21; an amalgamation of those two is the definition in the adopted rule. Because this definition is already used in federal rule, which potentially liable parties are subject to, we believe there is no change to either baseline.

2.3.3 Definition of "shoreline"

We do not analyze this change quantitatively.

"Shoreline" was not defined in either the RDA or NRDA baseline. It is defined in the adopted rule as: "any interface between the surface of the waters of the state, including wetlands, and sediment or soil".

This is fairly compatible to most commonly accepted definitions of shoreline, such as Ecology's Glossary of Coastal Terminology:

> "The intersection of a specified plane of water with [the] strip of ground bordering [that] body of water which is alternately exposed, or covered by tides and/or waves".

It is also more burdensome than definitions of "shoreline" in rule, such as the Shoreline Management Act (SMA) (RCW 90.58.030):

> "all of the water areas of the state, including reservoirs, and their associated shorelands, together with the lands underlying them; except (i) shorelines of statewide significance; (ii) shorelines on segments of streams upstream of a point where the mean annual flow is twenty cubic feet per second or less and the wetlands associated with such upstream segments; and (iii) shorelines on lakes less than twenty acres in size and wetlands associated with such small lakes".

The SMA definition encompasses a conceivably smaller universe of shorelines which in turn is associated with more recovery credit given to a spiller as there are fewer avenues for contact.

Liable parties receive less recovery credit and pay more damages with the adopted rule definition of "shoreline". We show in Chapter 5: Benefits of Adopted Rule however that one additional dollar paid in shoreline damages creates a greater than one dollar benefit in shoreline restoration over 20 years.[4] Therefore we expect this change to create net benefits.

However, Ecology could not determine the change in probability of contacting shoreline given the change in definition. We consequently only analyze this change qualitatively in this section. Again, we expect there will be a greater number of spills that contact "shoreline" under the adopted rule definition, and we expect this change to create net benefits because one additional dollar paid in shoreline damages creates a greater than one dollar benefit in shoreline restoration over 20 years.

2.3.4 Definition of "recovered oil"

We do not analyze this change quantitatively.

The term "recovered oil" is used in the RDA guidance, while section 173-870 uses the term "immediately removed oil". The "recovered oil" definition was created to address the cases where spilled oil contacts a shoreline, is remobilized back into the water (for example by flushing the beach sediments with high volumes of water), and then recovered off the water's surface. Oil recovered in this manner has impacts the beach, and resource injury occurs, and is not allowed to be used in the calculation of recovery credit.

There is conceivably a cost to liable parties in the form of smaller recovery credit, or greater damages. Ecology does not believe the quantity of oil remobilized at a given spill is significant, but does not have data on the percentage of oil spilled, that touches shoreline, is then remobilized into the water, and then recovered.

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[4] This is not true of damages in open water and its corresponding restoration however, as we show in
Chapter 4: Costs of Adopted Rule. This distinction is important and we elaborate in the analysis.

As such, Ecology does not analyze this change beyond the qualitative illustration in this section. Ecology does not have data on the percentage of oil spilled, that touches shoreline, is then remobilized into the water, and then recovered.

2.3.5 New form for liable parties to receive recovery credit

We do not analyze this change quantitatively.

Liable parties must fill out a new form in order to receive recovery credit. The old form was one page long; the new form is two pages long. There is conceivably a time cost to filling out a longer form.

From program experience, the information requested on the new form is all information a liable party is expected to already know (except for information requiring testing, addressed in sections 2.3.6 New testing of recovered oil and 2.3.8 New testing of specific gravity). We do not believe the addition of a second page incurs more than minor costs, and such costs are small enough to be unquantifiable.

Ecology does not analyze this change beyond the qualitative illustration in this section.

2.3.6 New testing of recovered oil

We analyze this change below in

Chapter 4: Costs of Adopted Rule.

To receive credit for oil in water or oil in debris, the liable party is now required to chemically analyze the substance. They must submit the test results to Ecology in order to determine the ratio of oil to water or oil to debris.

They are not required to test under either baseline. The costs of testing are a function of how many parties typically wish to apply for either credit.

2.3.7 Default for sorbent materials

We do not quantitatively analyze this change.

To determine the percentage of oil in sorbents, liable parties squeeze the sorbent material and collect everything that comes out – water and oil. What is left on the pad after squeezing is (theoretically) only oil. They are then able to weigh the squeezed pads, and compare the weight of the pads before use (the dry weight of the pads). A liable party then gets the total weight of water and oil.

A liable party is allowed to use the above squeeze and weigh method for a subset of their total sorbent materials, and then base the percentage of oil on the ratio determined from the squeeze method.

Under both baselines, if a liable party wishes to receive credit from sorbent materials, they may use the method described above, or they may haggle with Ecology. Under the adopted rule, they may use the method above or default to a percentage of 75 percent oil.

Ecology believes agents will act in their best interests, and squeeze if they believe their sorbent materials are comprised of greater than 75 percent oil.[5] If they believe otherwise, they will default to 75 percent, and receive greater credit. There is conceivably a time savings from not haggling. There is also conceivably a cost from less recovery credit, if under the baselines parties could haggle to a greater ratio than both the default ratio and the testing ratio. Ecology could not determine if these result in a net cost or benefit to liable parties.

Ecology believes such costs and benefits are minor, and unquantifiable. As a result, Ecology does not analyze this change beyond the qualitative illustration in this section.

2.3.8 New testing of specific gravity

We analyze this change below in

Chapter 4: Costs of Adopted Rule.

If a liable party wishes to receive the extra 24 hours (giving them 48 hours total to recover spilled oil) when they spill persistent oil, they must test the specific gravity to show it is in fact persistent oil.

The statute mandates the change such that persistent oils may be recovered in a time period up to 48 hours from the spill. The statute does not mandate liable parties test the specific gravity and submit it to Ecology. This is a cost Ecology has discretion over, and is a function of the cost of testing and how many spills of persistent oil occur.

Chapter 3: Historical Spills Data

To estimate the difference in damages between the adopted rule and respective baselines we must look at the historic parameter values of the spill vulnerability scores (SVS) and scores for oil (OIL).

We look at spills under the NRDA process from 1994 to the first half of 2012. We include the first half of 2012 because while there are only five observations, there are relatively few observations per year for the entire sample. We are specifically interested in the SVS and OIL coefficients, as well as the quantity of oil spilled and recovered. Note that spills going through the NRDA process are spills of 25 gallons or more to surface waters of the state.

Sometimes spills did not have information on one or more of the key parameters we are interested in – these observations were dropped. While there were initially 680 spills we had data

[5] Anecdotally, Ecology does not believe most sorbent materials would be comprised of more than 75 percent oil – a visual inspection of paper records suggests the average ratio is less (by approximately 5 percentage points). Ecology did not analyze this change quantitatively however because we believe such costs and benefits are minor, and unquantifiable.

on, our final data set consists of 306 observations after checking for duplicate or incomplete observations. The necessary assumption is that duplicate or incomplete observations are not correlated with the values of the coefficients.[6] The summary statistics for the estimated coefficients are shown in Table 3.

Table 3: Coefficient Data

Variable	Observations	Mean	Standard Deviation (Std. Dev.)	Minimum	Maximum
SVS_{MI}	306	19.4031	10.2798	0.6	50
SVS_{PER}	306	19.2124	10.2558	0.6	50
SVS_{AT}	306	20.0537	10.5209	0.6	50
OIL_{MI}	306	3.1542	0.7115	1	5
OIL_{PER}	306	2.3121	0.9555	1	5
OIL_{AT}	306	1.9931	1.0923	0	5

In Figure 1 and Figure 2 of Appendix A, we observe that the coefficient values have remained relatively constant over time. Simple linear regressions of each coefficient on year also show that the least squares estimators are not significantly different from zero at a 10 percent level.[7] The implication here is a lack of evidence for a non-zero trend over time, from our simple regression.[8] We therefore suggest a constant estimate (such as the sample mean) provides an accurate estimate for future parameter values. We provide a low and high estimate for the change in damages. These estimates correspond to using the mean coefficient values plus or minus one standard deviation, seen in Table 4. If for example the coefficient values follow a normal distribution, these bounds include approximately 68 percent of all observed coefficient values.

Table 4: Coefficient Estimates

Variable	Low	High
SVS_{MI}	9.1233	29.6830
SVS_{PER}	8.9566	29.4682
SVS_{AT}	9.5328	30.5747
OIL_{MI}	2.4428	3.8657
OIL_{PER}	1.3566	3.2676
OIL_{AT}	0.9008	3.0854

We also look at the mean gallons of recovered oil in a given year, for the years 1996-2011. For gallons recovered there are more observations per year (a mean of 28.125 observations per year from the years 1996-2011) than for the SVS and OIL coefficients, except for the years 1994 and 1995 (eight and three respectively) and 2012 (five observations). This gives us 467 observations. In Figure 3 of Appendix B we observe that for the years 1996-2011 the gallons recovered in a

[6] If for example incomplete observations are positively correlated with SVS_{MI}, our sample is biased because we have omitted spills with systematically higher values of SVS_{MI}. Our estimated coefficient would be smaller than its population value.

[7] Please see Appendix A.

[8] Please also note this does not necessarily imply there is no non-zero trend – it implies that given our data, we cannot say whether one exists.

year remain relatively constant. Furthermore, a simple regression of gallons of recovered oil on year does not suggest a significant trend over time,[9] even when we enlarge the sample size to include 1994-2012.[10] We therefore use the mean gallons recovered from 1996-2011 as our assumption for gallons recovered at a spill site in future years, seen in Table 5.

Table 5: Oil Spilled/Recovered

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
Spilled (gallons)	467	1,239.7100	13,034.3800	6	277,200
Recovered (gallons)	467	142.6831	519.0774	0	5,762
Recovery Ratio	467	0.2919	0.3589	0	1

To estimate these changes over the course of 20 years, we look at the historical number of spills that fall under the NDRA process, in a given year, for the years 1994-2011. We did not include the first half of the year 2012 because there were few observations in 2012 relative to the years 1994-2011. We look at all observations even if they had incomplete or missing data for our other parameters of interest (while there may be lapses in record-keeping of other parameters, we are still relatively certain the spill did occur); the number of observations are 573.

We find the mean number of spills is equal to 31.83 per year.

In Figure 4 of Appendix C we visually note the number of spills in a given year remains relatively constant from the years 1994-2011. We further note a simple regression of gallons of recovered oil on year does not suggest a significant trend over time.[11] We therefore use the mean number of spills as our assumption for number of future spills in a given year.

We then determine the historical usage of each compensation schedule (this is the historical percentage of spills in a given type of habitat), shown in Table 6. We see the majority of spills occur in marine and estuarine waters, followed by freshwater streams, rivers, or lakes. In Figure

[9] The coefficient on year is actually mildly significant (at a 10 percent level) before adjusting for robust (Huber-White) standard errors, which are appropriate when the differences between the fitted values and the data do not have the same variance across time. A quick glance at the differences between the fitted values and the data suggests this is true.
We do note however that we did not use robust errors on any other of our simple, illustrative regressions, but only the regression that obtains our (mildly) significant result. While this sort of emphasis on only a certain type of result may reek of "cargo cult science" (see Feynman, 1985), we also note that robust errors are more often than not larger than non-robust errors. As a result we would expect our other regressions to maintain non-significance even in the presence of robust errors (as the standard error gets larger, it is less likely to be significant, and robust errors are typically larger).
Lastly, it is also worth pointing out the coefficient on year is incredibly small and negative. This suggests that even if we took into account a negative trend, the number of spills over 20 years would only decrease marginally (by approximately 3 spills at the end of the 20-year period). We find it more convincing to use a constant trend, as well as simpler to calculate. In short, we do not believe we are "fooling ourselves".
[10] Please see Appendix B.
[11] Please see Appendix C.

5 and Figure 6 of Appendix D we observe these ratios do not change much over time, and regressions of the respective ratios on year do not suggest a significant trend over time.

Table 6: Location Ratios

Variable	Observations	Location ratio
Freshwater streams, rivers, lakes	609	.4023
Freshwater wetlands	609	.1199
Columbia River estuary	609	.0214
Marine estuarine waters	609	.4565

Because the compensation schedule changes depending on whether or not there is shoreline contact and containment, we must also look at their historical incidence, seen in Table 7. These are taken from the years 2004-2011, for all spills with a “Spill Vulnerability Score Worksheet” or “Attachment B: Explanation of Oil Spill Compensation Schedule Variables” in their paper record. Many spills do not have data on whether there was shoreline contact or containment, and looking at their compensation schedule to determine contact/containment is not an accurate alternate method.[12] There are a total of 145 total paper records from 2004-2011 – we only find recorded data in 66 of the spills. The necessary assumption is the incidence of shoreline contact or containment is not correlated with whether a spill recorded that data.

Table 7: Shoreline/Containment Ratios

Variable	Observations	Percentage of spills
No containment, no shoreline contact	66	0.1970
Containment, no shoreline contact	66	0.1818
No containment, shoreline contact	66	0.5758
Containment, shoreline contact	66	0.0455

In

Table 8 there are only 15 observations – this is because this table is comprised of all observations that obtain containment – only approximately 22.7 percent of spills obtain containment. Of these, we do not have any observations where there is no shoreline contact, containment, and a spill that extends past 1,000 feet, or any observations where there is shoreline contact, containment, and a spill within a 1,000 foot radius.

The intuition is if a spill extends greater than 1,000 feet, it is much more likely it will touch shore – the area it covers is larger. We also note there are not many observations where a spill is both contained and greater than 1,000 feet (only three observations) – if a spill extends past a 1,000 foot radius, it is likely because it is not contained.

[12] Because of time constraints and the discretionary nature of the compensation schedule, a spill might contact shoreline and still receive full recovery credit, for example if said contact is not noticed until after the determination of damages. Alternatively, a party may not receive full credit, and because we could not determine the specific compensation schedule (NRDA rule or RDA guidelines) used, we are not be able to determine if they did not receive full credit because the spill is greater than 1,000 feet of the origin, they had shoreline contact, or both.

In addition, if a spill is within a 1,000 foot radius, and contained, it is not very likely there is shoreline contact – there is less area covered and the spill is contained. Furthermore, we note of all the spills contacting shoreline, only three (the same three observations as above) are contained.

This of course does not mean these scenarios we assign zero probability to will never occur in the future. Our data set is relatively small and somewhat riddled with measurement error. However, given the data available to us, these are the best estimates we can provide at this time. We cannot say the two scenarios described above occurred from 2004-2011.

Table 8: Shoreline/1,000 Feet Ratios

Variable	Observations	Ratio
No shoreline contact, containment, less than 1,000 feet	15	0.8
Shoreline contact, containment, greater than 1,000 feet	15	0.2
No shoreline contact, containment, greater than 1,000 feet	15	0
Shoreline contact, containment, less than 1,000 feet	15	0

Finally, we look at the multiplier "x". While we do not analyze the change in the multiplier for spills greater than 1,000 gallons because of its non-discretionary nature, we do find the expected value of the multiplier for the purposes of estimating changes in future damages. From the adopted rule, the multiplier will take on the following values:

Compensation Schedule	Less than 1,000 gallons	Greater than 1,000 gallons
Freshwater wetlands	1.620	4.860
Freshwater streams, rivers, lakes	0.162	0.486
Columbia River estuary	0.508	1.524
Marine estuarine waters	0.208	0.624

On 606 observations we see approximately 10.23 percent of spills exceed 1,000 gallons. We also note in Appendix E that we find no evidence of a trend over time, both by casual observation of Figure 7 and a regression of ratio on year.

Our expected x is therefore equal to:

$$(1.62 * 0.4023 + 0.162 * 0.1199 + 0.508 * 0.2135 + 0.208 * 0.4565) * 0.8977$$
$$+(4.86 * 0.4023 + 0.486 * 0.1199 + 1.524 * 0.2135 + 0.624 * 0.4565) * 0.1023$$
$$= 1.0535.$$

To recap, our estimated parameter values are as follows:

Variable	Low	High
SVS_{MI}	9.1233	29.683
SVS_{PER}	8.9566	29.4682
SVS_{AT}	9.5328	30.5747
OIL_{MI}	2.4428	3.8657
OIL_{PER}	1.3566	3.2676
OIL_{AT}	0.9008	3.0854

Recovered (gallons)	108.24	108.24
x	1.0535	1.0535

Chapter 4: Costs of Adopted Rule

4.1 NRDA baseline

There are testing costs to both baselines we discuss below. The changes to the compensation schedule from the NRDA baseline all result in avoided costs to liable parties – described in Chapter 5: Benefits of Adopted Rule.

However, a smaller amount of damages paid by liable parties also results in less restoration of the environmental damage these spills cause. These environmental damages are particularly acute when there is shoreline contact – affecting the wetlands, marshes, and beaches of Washington State. Below, we illustrate the costs due to decreased restoration of environmental habitats.

When there is shoreline contact, a liable party pays smaller damages under the adopted rule; the difference per spill is equal to:

$$Damages(\$)_{Prop\_b} - Damages(\$)_{NRDA\_b} =$$
$$Damages(\$)_{Prop\_d} - Damages(\$)_{NRDA\_b} =$$
$$-x * [(OIL_{PER} * SVS_{PER} * gallons\ recovered\ in\ 24\ hours)].$$

Low	High
$1,385.53	$10,980.06

This is expected to happen approximately 62 percent of the time (see Table 7).

This results in less restoration when spills reach respective wetlands, marshes, or beaches – damages paid by liable parties have a one to one relationship to the corresponding restoration of the affected habitats. We assume there is shoreline contact 62 percent of the time, and 31.83 spills per year as illustrated in Chapter 3: Historical Spills Data. We also derive a cost of approximately $252,873 to restore or mitigate one acre of damage by looking at nine observations from the 2003-2009 Washington State Department of Transportation Cost Studies for Concurrent Mitigation. These nine observations correspond to wetlands restoration projects. Our cost per acre is the average cost of those nine studies. While potentially liable parties may also be restoring salt marshes, eelgrass beds, etc., we assume wetlands restoration is a suitable proxy for costs per acre. The costs of these restorations are the best known data to Ecology at this time.

The expected acres forgone are the damages a liable party no longer has to pay under the adopted rule, divided by the cost of mitigating one acre.

We then derive the expected benefits from one restored acre. This depends on where the spills occur and we use the probabilities of location found in Table 6, and the following average amenity values per acre per year from an Earth Economics publication “Valuing the Puget Sound Basin”.

Table 9: Amenity Values

Affected Shoreline	Minimum amenity per acre	Maximum amenity value per acre	Average amenity value per acre
Wetlands	$14,377.14	$71,103.69	$42,740.42
Columbia Estuary – Salt Marsh	$358.74	$114,739.48	$57,549.11
Lakes/Rivers - Beaches	$22,353.32	$81,528.01	$51,940.67
Marine Estuaries – Eelgrass Beds	$5,507.00	$15,421.00	$10,464.00
Open Water Estuary	$110.15	$1,863.11	$986.63

We assume shoreline affected in the Columbia Estuary would be salt marshes, shoreline affected in all other marine estuaries would be eelgrass beds, and lakes/rivers would have shorelines of beaches. These amenity values include and are not limited to the benefits from water supply, aesthetic and recreational uses, habitat use, and water flow regulation.

The expected amenity value per acre per year of shoreline restoration is then just the probability of a spill occurring in one of those locations, multiplied by the corresponding average amenity value per acre per year, or approximately $32,029.

Given the above assumptions we find the costs of forgone restoration, of approximately 2 to 17 expected acres at the end of 20 years. These estimates are discounted at an annual rate of 1.58 percent.

Table 10: Forgone Restoration (NRDA Shorelines)

Year	Expected minimum acres forgone	Expected maximum acres forgone		Minimum amenity value forgone	Maximum amenity value forgone
2013	0.1084	0.8587		$3,416.51	$27,075.16
2014	0.2167	1.7174		$6,726.73	$53,308.02
2015	0.3251	2.5761		$9,933.15	$78,718.29
2016	0.4334	3.4348		$13,038.20	$103,325.26
2017	0.5418	4.2935		$16,044.25	$127,147.62
2018	0.6501	5.1522		$18,953.63	$150,203.86
2019	0.7585	6.0109		$21,768.62	$172,512.13
2020	0.8668	6.8696		$24,491.48	$194,090.25
2021	0.9752	7.7283		$27,124.34	$214,955.22
2022	1.0836	8.5870		$29,669.37	$235,124.04
2023	1.1919	9.4457		$32,128.68	$254,613.67
2024	1.3003	10.3044		$34,504.29	$273,439.88
2025	1.4086	11.1631		$36,798.23	$291,618.94
2026	1.5170	12.0218		$39,012.49	$309,166.53
2027	1.6253	12.8805		$41,148.90	$326,097.18
2028	1.7337	13.7392		$43,209.50	$342,427.05
2029	1.8420	14.5979		$45,195.98	$358,169.52

2030	1.9504	15.4566		$47,110.19	$373,339.26
2031	2.0588	16.3153		$48,953.96	$387,950.75
2032	2.1671	17.1740		$50,729.01	$402,017.68
			Total	$589,957.51	$4,675,300.32

We also note approximately 38 percent of the time there is no shoreline contact, and 47 percent of the time when there is no shoreline contact, there is also containment. When this occurs, a liable party pays a smaller amount of damages under the adopted rule; the difference is equal to:

$$Damages(\$)_{Prop\_a} - Damages(\$)_{NRDA\_a} = Damages(\$)_{Prop\_c} - Damages(\$)_{NRDA\_a} = -x * 0.9 * [(OIL_{MI} * SVS_{MI} * gallons\ recovered\ in\ 24\ hours) + (OIL_{PER} * SVS_{PER} * gallons\ recovered\ in\ 24\ hours)]\ .$$

Low	High
$3,534.18	$21,658.14

The other 53% of the time (when there is no shoreline contact and no containment), because there is no shoreline contact a liable party will pay a smaller amount of damages, the difference equal to:

$$Damages(\$)_{Prop\_b} - Damages(\$)_{NRDA\_b} = Damages(\$)_{Prop\_d} - Damages(\$)_{NRDA\_b} = -x * [(OIL_{PER} * SVS_{PER} * gallons\ recovered\ in\ 24\ hours)].$$

Low	High
$1,385.53	$10,980.06

The expected difference in damages when there is no shoreline contact is therefore equal to $2395.40 on the low end and $15,998.76 on the high end.

The average amenity value of open water restoration is $986.63. Maintaining the same assumptions as above, while substituting in the probability of no shoreline contact and the average amenity value of open water restoration, we also find costs of forgone open water restoration. These estimates are discounted at an annual rate of 1.58 percent.

Table 11: Forgone Restoration (NRDA Open Water)

Year	Expected minimum acres forgone	Expected maximum acres forgone		Minimum amenity value forgone	Maximum amenity value forgone
2013	0.1146	0.7653		$111.29	$743.28
2014	0.2292	1.5305		$219.11	$1,463.43
2015	0.3437	2.2958		$323.55	$2,161.00
2016	0.4583	3.0610		$424.70	$2,836.52
2017	0.5729	3.8263		$522.61	$3,490.50
2018	0.6875	4.5915		$617.38	$4,123.44

2019	0.8020	5.3568		$709.07	$4,735.86
2020	0.9166	6.1220		$797.76	$5,328.23
2021	1.0312	6.8873		$883.53	$5,901.02
2022	1.1458	7.6525		$966.42	$6,454.70
2023	1.2603	8.4178		$1,046.53	$6,989.74
2024	1.3749	9.1830		$1,123.91	$7,506.56
2025	1.4895	9.9483		$1,198.63	$8,005.62
2026	1.6041	10.7135		$1,270.76	$8,487.34
2027	1.7186	11.4788		$1,340.35	$8,952.12
2028	1.8332	12.2440		$1,407.47	$9,400.42
2029	1.9478	13.0093		$1,472.18	$9,832.58
2030	2.0624	13.7745		$1,534.53	$10,249.03
2031	2.1770	14.5398		$1,594.58	$10,650.15
2032	2.2915	15.3050		$1,652.40	$11,036.32
			Total	$19,216.77	$128,347.84

4.2 RDA baseline

If there is no containment, the RDA guidelines and the adopted rule have identical compensation schedules.

When there is containment, but the spill extends out less than 1,000 feet and there is no shoreline contact, the RDA guidelines and the adopted rule have identical compensation schedules.

If there is no containment, shoreline contact, and the spill does not extend 1,000 feet, damages are greater under the adopted rule, and the difference equals:

$$Damages(\$)_{Prop\_b} - Damages(\$)_{RDA\_a} =$$
$$x * \left[\left(OIL_{MI} * SVS_{MI} * (gallons\ recovered\ in\ 24\ hours)\right)\right].$$

However, as we see in

Table 8, we cannot expect this scenario to unfold. This of course does not mean these scenarios we assign zero probability to will never occur in the future. Our data set is relatively small and somewhat riddled with measurement error. However, given the data available to us, these are the best estimates we can provide at this time. We cannot say this scenario occurs in the time period from 2004-2011.

Finally, if there is no containment, shoreline contact, and the spill extends past 1,000 feet, damages are greater under the adopted rule, and the difference between the two will equal:

$$Damages(\$)_{Prop\_b} - Damages(\$)_{RDA\_b} =$$
$$x * \left[\left(OIL_{MI} * SVS_{MI} * (gallons\ recovered\ within\ 1{,}000\ feet\ in\ 24\ hours)\right)\right].$$

Low estimate per spill	High estimate per spill
$2,541.34	$13,084.53

We use the average of approximately 108 gallons recovered to calculate the estimates above. We note the difference is likely less – liable parties only receive credit for the gallons recovered within 1,000 feet of the origin of the spill, while we've used our estimate of total gallons recovered. It is difficult for OSCs to determine exactly where a 1,000 foot radius starts; as such, data on the percentage of the spill outside of 1,000 feet is not kept. We assume the upper bound of increased damages to liable parties.

Roughly 22.7 percent of our 66 observations obtain containment, and 80 percent of those extend out less than 1,000 feet and do not touch shoreline. These scenarios all imply no change in damages between the RDA guidelines and adopted rule.

The other 20 percent (of the 22.7 percent that obtained containment) do contact shoreline, and extend out greater than 1,000 feet. This implies this scenario only occurs in approximately 4.6 percent of spills.[13]

We then take the expected change in damages and multiply it by the expected number of spills in a year, discounted, and obtain the following benefits over a 20-year period in Table 12.

Table 12: Increased Damages (RDA)

Year	Low	High
2013	$3,620.04	$18,638.42
2014	$3,563.73	$18,348.51
2015	$3,508.30	$18,063.11
2016	$3,453.73	$17,782.16
2017	$3,400.01	$17,505.57
2018	$3,347.12	$17,233.28
2019	$3,295.06	$16,965.23
2020	$3,243.81	$16,701.35
2021	$3,193.36	$16,441.57
2022	$3,143.69	$16,185.84
2023	$3,094.79	$15,934.08
2024	$3,046.65	$15,686.24
2025	$2,999.26	$15,442.25
2026	$2,952.61	$15,202.06
2027	$2,906.69	$14,965.60
2028	$2,861.47	$14,732.82
2029	$2,816.97	$14,503.66
2030	$2,773.15	$14,278.07
2031	$2,730.02	$14,055.98
2032	$2,687.55	$13,837.35

[13] As the reader no doubt notices, this also implies that of the observations that obtained observations extend out less than 1,000 feet and touch shoreline, or extend out greater than 1,000 contact shoreline, as shown in

Table 8.

Total	$62,638.00	$322,503.15

4.3 Costs to both baselines

The addition of requiring testing, if a liable party wishes to receive credit for oil in water or oil in debris, is a change from both baselines. We look from the record of spills from 2004-2012 and find 79 observations receiving recovery credit. Of those, we note whether they apply for credit from oil in water or oil in debris, by looking at the "Preassessment Screening Oil Spill Report Form" and the "Recovered Oil Data Form" in their paper record

We note approximately 22 percent of parties apply for oil in water recovery credit over this time span, and approximately six percent of parties apply for oil in debris credit as well. For each area (such as a vacuum truck) they want considered, a liable party must submit two samples. We assume each spill has only one vacuum truck, and therefore only submits two samples. In order to test for oil in water or oil in debris a liable party must also know the chemical range of their oil. We assume each spill also requires one test to determine the chemical range of the oil.

We query Manchester Laboratory as to the cost of testing oil in water or oil in debris. The cost for a single test equals $130 (NWTPH-Dx test for oil in water) and $145 (NWTPH-Dx test for oil in debris) respectively. The tests for the chemical range of the oil cost $70 (HCID test for oil in water) and $85 (HCID test for oil in debris) respectively. We assume on average a single spill requires two NWTPH-Dx tests and one HCID test to determine the ratio of either oil in water or debris. The total costs, discounted at an annual rate of 1.58 percent, are given in Table 13.

Table 13: Oil in Water/Debris Testing

Year	Oil in water testing costs	Oil in debris testing costs
2013	$2,225.18	$743.71
2014	$2,190.56	$732.14
2015	$2,156.49	$720.75
2016	$2,122.95	$709.54
2017	$2,089.93	$698.51
2018	$2,057.42	$687.64
2019	$2,025.42	$676.94
2020	$1,993.92	$666.42
2021	$1,962.90	$656.05
2022	$1,932.37	$645.85
2023	$1,902.31	$635.80
2024	$1,872.72	$625.91
2025	$1,843.60	$616.17
2026	$1,814.92	$606.59
2027	$1,786.69	$597.16
2028	$1,758.90	$587.87
2029	$1,731.54	$578.72
2030	$1,704.61	$569.72

2031	$1,678.09	$560.86
2032	$1,651.99	$552.14
	$38,502.52	$12,868.49
	Total	$51,371.01

A liable party must also test the specific gravity of their oil if they wish to receive the extra time to recover given the oil is persistent.

We look at all spills from 1994-2012 that record the type of oil spill, and count the number that spill either: bunker oil, intermediate fuel oil, crude oil, or asphalt oil. We determine that out of 450 total observations, only 19 spill persistent oils, and therefore only approximately 4.2 percent of spills might desire to test their specific gravity.[14] For the purposes of this estimation, we assume all spillers of persistent oil will want the extra 24 hours to recover.

From Test America, a certified lab in Tacoma, Washington, we obtain an estimate of $25 per sample to test specific gravity. We note many shippers of persistent oil already have lab data giving either the gravity or density of the oil at the time of shipment. However, we assume all shippers still incur the cost of testing.

We find that the discounted cost of testing for specific gravity over 20 years, assuming approximately 31 spills per year, and the additional assumptions illustrated above, is equal to $569.30.

Chapter 5: Benefits of Adopted Rule

5.1 NRDA baseline

The changes from the NRDA baseline are always avoided damages, and are organized under the benefits section of this analysis. Under the adopted rule, the damages a liable party has to pay (attributable to the discretionary portions of the rule) are always less than the damages they have to pay under the NRDA baseline.

If there is containment and no shoreline contact, a liable party pays a smaller amount of damages under the adopted rule; the difference is equal to:

$$Damages(\$)_{Prop\_a} - Damages(\$)_{NRDA\_a} =$$
$$Damages(\$)_{Prop\_c} - Damages(\$)_{NRDA\_a} = -x * 0.9 * [(OIL_{MI} * SVS_{MI} *$$
$$gallons\ recovered\ in\ 24\ hours + OILPER * SVSPER * gallons\ recovered\ in\ 24\ hours$$
.

Low	High
$3,534.18	$21,658.14

This is expected to happen approximately 18 percent of the time (see Table 7).

[14] Please see Table 17 in Appendix F.

When there is no containment and/or shoreline contact, a liable party pays smaller damages under the adopted rule; the difference is equal to:

$$Damages(\$)_{Prop\_b} - Damages(\$)_{NRDA\_b} =$$
$$Damages(\$)_{Prop\_d} - Damages(\$)_{NRDA\_b} =$$
$$-x * [(OIL_{PER} * SVS_{PER} * gallons\ recovered\ in\ 24\ hours)].$$

Low	High
$1,385.53	$10,980.06

This is expected to happen approximately 82 percent of the time (see Table 7).

Taking the expected change in damages and multiplying it by the expected number of spills in a year, discounted, we obtain the following benefits over a 20-year period in Table 14.

Table 14: Decreased Damages (NRDA)

Year	Low	High
2013	$55,662.77	$404,936.97
2014	$54,796.98	$398,638.48
2015	$53,944.65	$392,437.96
2016	$53,105.59	$386,333.88
2017	$52,279.57	$380,324.75
2018	$51,466.40	$374,409.09
2019	$50,665.88	$368,585.44
2020	$49,877.81	$362,852.37
2021	$49,102.00	$357,208.48
2022	$48,338.25	$351,652.37
2023	$47,586.39	$346,182.68
2024	$46,846.22	$340,798.07
2025	$46,117.56	$335,497.22
2026	$45,400.24	$330,278.81
2027	$44,694.07	$325,141.58
2028	$43,998.89	$320,084.25
2029	$43,314.52	$315,105.58
2030	$42,640.79	$310,204.35
2031	$41,977.55	$305,379.35
2032	$41,324.62	$300,629.41
Total	$963,140.74	$7,006,681.10

5.2 RDA baseline

There is only one scenario under the RDA under the baseline as opposed to the rule (where liable parties might avoid costs). As seen in Chapter 4: Costs of Adopted Rule, there are scenarios where damages do not change – we do not repeat them here.

When there is containment, no shoreline contact, and the spill extends past 1,000 feet radius, damages are greater under the RDA baseline, and the difference equals:

$$Damages(\$)_{Prop\_a} - Damages(\$)_{RDA\_b} =$$
$$-x\big[\big(OIL_{MI} * SVS_{MI} *$$
$$gallons\ recovered\ in\ 24\ hours - gallons\ recovered\ within\ 1{,}000\ feet\ in\ 24\ hours.$$

As we see in

Table 8, we cannot expect this scenario to unfold. From 2004-2012, we do not come across a spill where these criteria were met. This of course does not mean the scenarios we assign zero probability to will never occur in the future. Our data set is relatively small and somewhat riddled with measurement error. However, given the data available to us, these are the best estimates we can provide at this time. From 2004-2011 we cannot say the above scenario exists.

There is however a benefit from increased restoration of damaged habitats. As mentioned above, these environmental damages are particularly acute when there is shoreline contact. This affects the wetlands, marshes, and beaches of Washington State. Under the adopted rule, liable parties pay more damages when there is shoreline contact and containment, specifically $2,541.34 to $13,084.53 per spill, with a probability of approximately 4.6 percent.

This results in more restoration when spills reach respective wetlands, marshes, or beaches – damages paid by liable parties have a one to one relationship to the corresponding restoration of the affected habitats. We assume there is shoreline contact and containment 4.6 percent of the time,[15] and 31.83 spills per year as illustrated in Chapter 3: Historical Spills Data. We also derive a cost of approximately $252,873 to restore or mitigate one acre of damage by looking at nine observations from the 2003-2009 Washington State Department of Transportation Cost Studies for Concurrent Mitigation. These nine observations correspond to wetlands restoration projects. Our cost per acre is the average cost of those nine studies. While potentially liable parties may also be restoring salt marshes, eelgrass beds, etc., we assume wetlands restoration is a suitable proxy for costs per acre. These costs of restoration are also the best known data to Ecology at this time.

[15] We only look at the increased restoration when there is both shoreline contact and containment because when there is shoreline contact and no containment, the damages under the RDA baseline and the adopted rule are the same – liable parties do not pay greater damages, and there is also no additional restoration.

The expected acres restored are then just the additional damages a liable party pays under the adopted rule, divided by the cost of mitigating one acre.

We then derive the expected benefits from one restored acre – this depends on where the spills occur, and we use the probabilities of location found in Table 6, and the average amenity values per acre from an Earth Economics publication "Valuing the Puget Sound Basin" found in Table 9.

Given the above assumptions, including an expected amenity value per acre of approximately $32,029, we find the benefits of increased restoration of approximately 0.3 to 1.5 expected acres at the end of 20 years. These estimates are discounted at an annual rate of 1.58 percent.

Table 15: Increased Restoration (RDA Shorelines)

Year	Expected minimum acres restored	Expected maximum acres restored		Minimum amenity value restored	Maximum amenity value restored
2013	0.0147	0.0758		$463.97	$2,388.81
2014	0.0294	0.1515		$913.50	$4,703.30
2015	0.0441	0.2273		$1,348.93	$6,945.21
2016	0.0589	0.3030		$1,770.60	$9,116.25
2017	0.0736	0.3788		$2,178.83	$11,218.07
2018	0.0883	0.4546		$2,573.92	$13,252.29
2019	0.1030	0.5303		$2,956.20	$15,220.52
2020	0.1177	0.6061		$3,325.97	$17,124.33
2021	0.1324	0.6819		$3,683.52	$18,965.22
2022	0.1471	0.7576		$4,029.13	$20,744.69
2023	0.1619	0.8334		$4,363.11	$22,464.23
2024	0.1766	0.9091		$4,685.72	$24,125.25
2025	0.1913	0.9849		$4,997.24	$25,729.16
2026	0.2060	1.0607		$5,297.94	$27,277.36
2027	0.2207	1.1364		$5,588.07	$28,771.13
2028	0.2354	1.2122		$5,867.90	$30,211.89
2029	0.2502	1.2880		$6,137.66	$31,600.83
2030	0.2649	1.3637		$6,397.62	$32,939.24
2031	0.2796	1.4395		$6,648.00	$34,228.39
2032	0.2943	1.5152		$6,889.06	$35,469.50
			Total	$80,116.88	$412,495.68

Chapter 6: Conclusion

Table 16 shows the expected costs and expected benefits to the people of the state of Washington over 20 years, discounted at an annual rate of 1.58 percent, and compares total costs to total benefits.

Table 16: Costs and Benefits

Costs (NRDA)	Low	High
Forgone restoration (shorelines)	$589,957.51	$4,675,300.32
Forgone restoration (open water)	$19,216.77	$128,347.84
Costs (RDA)		
Increased damages paid by liable parties	$62,638.00	$322,503.15
Costs (both baselines)		
Required testing (oil in water, oil in debris)	$51,371.01	$51,371.01
Required testing (specific gravity)	$569.30	$569.30
Benefits (NRDA)	Low	High
Decreased damages paid by liable parties	$963,140.74	$7,006,681.10
Benefits (RDA)		
Increased restoration (shorelines)	$80,116.88	$412,495.68
NRDA total costs	$661,114.59	$4,855,588.47
NRDA total benefits	$963,140.74	$7,006,681.10
RDA total costs	$114,578.31	$374,443.46
RDA total benefits	$80,116.88	$412,495.68

This story illustrates a potentially interesting tradeoff: the benefits from damages paid from liable parties are worth more when the spills impact shorelines as opposed to spills that stay in the open water. This explains why we can increase damage payments and increase restorations compared to the RDA baseline and have benefits outweigh the costs, and decrease damage payments and decrease restorations compared to the NRDA baseline while achieving the same outcome.

In comparison with the RDA baseline, damage assessments only increase when there is shoreline contact. An additional dollar spent on shoreline restoration is worth much more than a dollar spent on open water restoration however. While the damage assessments of restoration in open water don't change in comparison with the RDA baseline, they do change in comparison with the NDRA baseline. Although we've decreased the restoration compared to the NRDA baseline, part of the forgone restoration is in the open water, where each additional dollar is worth much less. In short, to some extent, we should decrease the damage assessment to parties who spill in open water, or increase the damages to parties who impact shorelines, as the adopted rule does.

This may be an artifact of our data. We value shorelines more than open water, and we assume mitigation costs of the two are identical. The results may change if these assumptions no longer hold (such as if restoration of open water is relatively less expensive). We do note however that even if restoration of open water cost half as much per acre as wetlands restoration, the overall results we obtained above would hold easily. This is because the amenity benefits of shorelines per acre are more than an order of magnitude greater than the amenity benefits of open water per acre.

We see the present value of the respective low and high estimates of the benefits exceed the respective low and high estimates of the costs, compared to the NRDA baseline (the current rule and legal baseline). We also note that while the low estimate of the costs exceeds the low estimate of the benefits under the RDA baseline, the high estimate of the benefits are greater than the high estimate of the costs. Ecology concludes based on a qualitative and quantitative assessment of the likely costs and benefits there is a reasonable likelihood the estimated benefits of the rule amendments exceed their costs.

Chapter 7: Least Burdensome Alternative Analysis

7.1 Introduction

RCW 34.05.328(1)(e) requires Ecology to "determine, after considering alternative versions of the rule and the analysis required under (b), (c), and (d) of this subsection, that the rule being adopted is the least burdensome alternative for those required to comply with it that will achieve the general goals and specific objectives stated under (a) of this subsection."

Ecology assesses alternatives to the rule amendments, and determines whether they met the general goals and specific objectives of the authorizing statute. Of those meeting these objectives, Ecology determines whether the rule amendments are the least burdensome.

7.2 General goals and specific objectives of the authorizing statutes

In 2011 the Washington State Legislature passed House Bill (HB) 1186 and the bill was codified in state law (Chapter 90.48 RCW). The legislation requires Ecology to amend its current compensation schedule. Under the new law, the amount of compensation assessed for spills is between:

- $1 and $100 per gallon of oil spilled when the spill is less than 1,000 gallons.
- $3 and $300 per gallon of oil spilled when the spill is equal to or more than 1,000 gallons.

The legislation also requires Ecology to deduct the volume of persistent oil recovered in 48 hours from the total spill volume when determining compensation amounts. The historical "recovery credit" process has been implemented through guidance promulgated in 1996 by the RDA Committee. This guidance needs to be moved into rule.

Ecology's rule language achieves two things:

- Makes the monetary damage liability consistent with changes in HB 1186.
- Addresses how recovery credits are provided for "persistent" oil, also required by HB 1186.

The basic premise for recovery credit is that early action (containment and removal) reduces resource exposure and injury. The general goal of NRDA is compensation to the public for resource injury. If a potentially liable party takes action reducing injury, then they get credit for it. This is an incentive for early and positive action as well.

7.3 Alternative rule content considered

For the definition of "shoreline" Ecology worked with the RDA Committee to ensure the adverse impacts from spilled oil are kept to a minimum. There are several definitions of shoreline in existence and Ecology wants to make sure current definitions are not impacted. Ecology also wants to make sure many surface water types (marine, rivers and lakes) are included.

The "persistent" oil definition is derived mainly from the federal definition for both the USCG and EPA. Also, the Contingency Plan Rule (WAC 173-182) already had definitions for persistent and non-persistent oil. Ecology only added the non-petroleum oils because Washington has non-petroleum oil manufacturing and transport.

The term "recovered oil" is only used by the guidance, while section 173-870 uses the term "immediately removed oil". The "recovered oil" definition is created to address the cases where spilled oil impacts a shoreline, is remobilized as a clean-up technique and then recovered off the water's surface. This occurs in the shoreline clean-up technique called "low pressure high volume flushing". Shoreline clean-up workers flush the beach sediments with high volumes of water, remobilizing the stranded oil back into the water. The remobilized oil is then recovered using a skimmer or with sorbent material, from the surface of the water. Oil recovered in this manner impacts the beach, and resource injury occurs. Clams and worms are exposed to the toxins in the oil and the flushing action most likely causes some mechanical injury to the soft tissues of worms. This remobilized oil is recovered off the surface of the water, but has already caused adverse impacts and should not be allowed to be used for recovery credit purposes. Ecology believes allowing such credit does not fulfill the goals and objectives of the law.

The Current Oil Recovery Credit Form (ECY 050-49)[16] has been used in guidance since 1996. This form was never required to be used. The information it generated was given to Ecology in order for a potentially liable party to get recovery credit. Because the form was not required, several clean-up contractors developed their own spreadsheets for documenting the required volumes. Liable parties have supplied incorrect information. This resulted in time spent resubmitting information. To avoid these types of errors, the new form is as explicit as possible. Areas requiring laboratory analysis for proper concentration or volume determinations are clearly marked.

From the NRDA baseline, there is a savings to liable parties from smaller damages. These savings were not mandated in statute. Ecology believes smaller damages are less burdensome for those required to comply with the adopted rule. We also believe the compensation schedule under the adopted rule fulfills the goals and objectives of the law. The recovery credit process was originally driven by environmental consequences. It also happens to be an incentive to get a

[16] Current Oil Recovery Credit Form

liable party to perform aggressive response actions. There are costs associated with all of the requirements to gain recovery credit, such as documentation and segregation of recovered oil, spent sorbent materials, or oiled debris. The PLP is to weigh the advantages of tracking these waste streams and their associated costs versus the amount of credit they may get for the damage assessment process. This is especially true for spills or larger volumes where the NRDA process may be conducted by federal trustees, and the entire compensation schedule process and recovery credit have no bearing.

Works Cited

Department of Ecology, WA State. (2004). *ECY 050-49: Oil Recovery Credit Form.*

Department of Ecology, WA State. (1998). *Publication No. 98-105: Glossary of Coastal Terminology.*

Earth Economics. (2010). *Valuing the Puget Sound Basin.*

EPA. (2012). *40 CFR: Protection of Environment.*

Feynman, R. (1985). *"Surely You're Joking, Mr. Feynman!": Adventures of a Curious Character - 1974 Caltech Commencement Address.* New York: W.W. Norton.

RDA Committee. (2004). *RDA Committee Resolution 96-1.1: Washington Oil Spill Compensation Schedule Credit for Oil Recovery.*

United States. (1990). *101 H.R.1465, P.L. 101-380: Oil Pollution Act.*

US Treasury Department. (2012). *http://www.treasurydirect.gov/indiv/research/indepth/ibonds/res_ibonds_iratesandterms.htm.* Retrieved from Rates and Inflation for I-Bonds, 1998-2011.

USCG. (2012). *33 CFR: Navigation and Navigable Waters.*

WA State. (2009). *Chapter 173-183 WAC: Oil Spill Natural Resource Damage Assessment.*

WA State. (2011). *Chapter 90.48 RCW: Water Pollution Control.*

WA State. (2011). *House Bill1186: Concerning requirements under the state's oil spill program.*

WA State. (2011). *RCW 34.05: Administrative Procedures Act.*

WA State. (2010). *RCW 90.58.030: Shoreline Management Act.*

WSDOT. (2006). *Cost Studies for Concurrent Mitigation: I 405 Kirkland--SR 520 to SR 522.*

WSDOT. (2003). *Cost Studies for Concurrent Mitigation: I 90 Issaquah.*

WSDOT. (2006). *Cost Studies for Concurrent Mitigation: I-5 548th to Pacific.*

WSDOT. (2006). *Cost Studies for Concurrent Mitigation: I-5 Everett.*

WSDOT. (2009). *Cost Studies for Concurrent Mitigation: I-5/SR 502 Interchange.*

WSDOT. (2009). *Cost Studies for Concurrent Mitigation: SR 16 Burley Olalla Interchange.*

WSDOT. (2003). *Cost Studies for Concurrent Mitigation: SR 18 Hobart.*

WSDOT. (2003). *Cost Studies for Concurrent Mitigation: SR 18 Maple Valley.*

WSDOT. (2006). *Cost Studies for Concurrent Mitigation: SR 18 Union to Jackson Ave.*

WSDOT. (2003). *Cost Studies for Concurrent Mitigation: SR 202 Redmond to SR 520.*

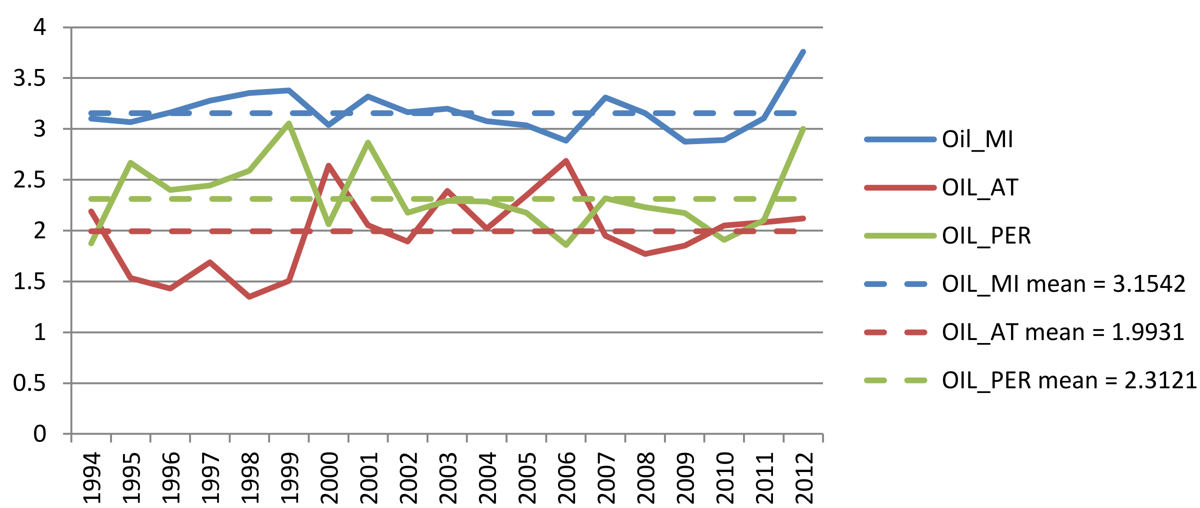
WSDOT. (2009). *Cost Studies for Concurrent Mitigation: SR 270 Pullman to Idaho State Line.*

WSDOT. (2009). *Cost Studies for Concurrent Mitigation: SR 539 Ten Mile Rd. to SR 546 Widening - Stage 1.*

Appendix A

Figure 1: SVS Coefficients

Figure 2: OIL Coefficients

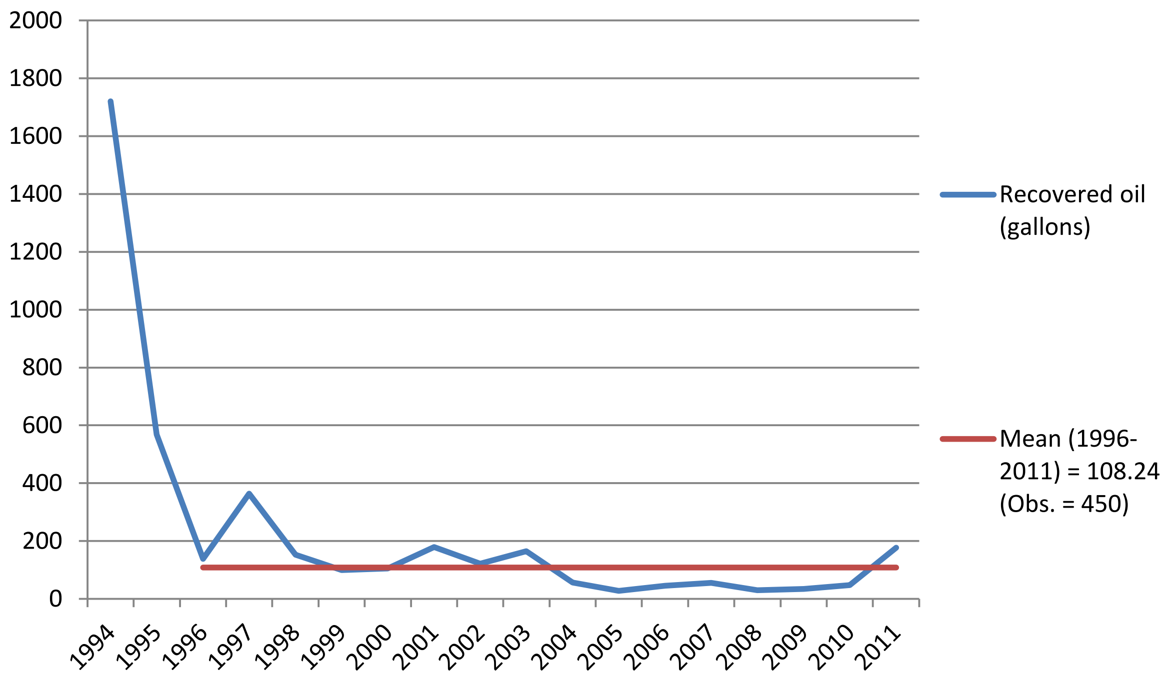


```
. reg svs_mi year

      Source |       SS       df       MS              Number of obs =      19
-------------+------------------------------           F(  1,    17) =    0.89
       Model |  14.6472817     1  14.6472817           Prob > F      =  0.3593
    Residual |  280.454941    17  16.4973495           R-squared     =  0.0496
-------------+------------------------------           Adj R-squared = -0.0063
       Total |  295.102223    18  16.3945679           Root MSE      =  4.0617

------------------------------------------------------------------------------
      svs_mi |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |   .1603028   .1701256     0.94   0.359    -.1986308    .5192364
       _cons |  -301.2793   340.7628    -0.88   0.389    -1020.226    417.6674
------------------------------------------------------------------------------

.
. reg svs_at year

      Source |       SS       df       MS              Number of obs =      19
-------------+------------------------------           F(  1,    17) =    1.02
       Model |  18.0902553     1  18.0902553           Prob > F      =  0.3275
    Residual |  302.622031    17  17.8012959           R-squared     =  0.0564
-------------+------------------------------           Adj R-squared =  0.0009
       Total |  320.712286    18  17.8173492           Root MSE      =  4.2192

------------------------------------------------------------------------------
      svs_at |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |   .1781496   .1767211     1.01   0.328    -.1946993    .5509985
       _cons |  -336.3477   353.9737    -0.95   0.355    -1083.167    410.4715
------------------------------------------------------------------------------

.
. reg svs_per year

      Source |       SS       df       MS              Number of obs =      19
-------------+------------------------------           F(  1,    17) =    0.60
       Model |  9.74178895     1  9.74178895           Prob > F      =  0.4481
    Residual |  274.613535    17  16.1537374           R-squared     =  0.0343
-------------+------------------------------           Adj R-squared = -0.0225
       Total |  284.355324    18   15.797518           Root MSE      =  4.0192

------------------------------------------------------------------------------
     svs_per |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |    .130732   .1683446     0.78   0.448     -.224444     .485908
       _cons |  -242.2303   337.1954    -0.72   0.482    -953.6505    469.1898
------------------------------------------------------------------------------
```

```
. reg oil_mi year

      Source |       SS       df       MS              Number of obs =      19
-------------+------------------------------           F(  1,    17) =    0.01
       Model |  .000360607     1  .000360607           Prob > F      =  0.9308
    Residual |  .789919461    17  .046465851           R-squared     =  0.0005
-------------+------------------------------           Adj R-squared = -0.0583
       Total |  .790280068    18  .043904448           Root MSE      =  .21556

------------------------------------------------------------------------------
      oil_mi |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |  -.0007954   .0090288    -0.09   0.931    -.0198445    .0182537
       _cons |   4.758773   18.08473     0.26   0.796    -33.39668    42.91422
------------------------------------------------------------------------------

.
. reg oil_at year

      Source |       SS       df       MS              Number of obs =      19
-------------+------------------------------           F(  1,    17) =    2.53
       Model |  .336913194     1  .336913194           Prob > F      =  0.1301
    Residual |  2.26397895    17  .133175232           R-squared     =  0.1295
-------------+------------------------------           Adj R-squared =  0.0783
       Total |  2.60089215    18  .144494008           Root MSE      =  .36493

------------------------------------------------------------------------------
      oil_at |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |   .0243121   .0152853     1.59   0.130    -.0079371    .0565612
       _cons |  -46.72096   30.61659    -1.53   0.145    -111.3163    17.87441
------------------------------------------------------------------------------

.
. reg oil_per year

      Source |       SS       df       MS              Number of obs =      19
-------------+------------------------------           F(  1,    17) =    0.50
       Model |  .065237727     1  .065237727           Prob > F      =  0.4884
    Residual |  2.21107816    17  .130063421           R-squared     =  0.0287
-------------+------------------------------           Adj R-squared = -0.0285
       Total |  2.27631589    18  .126461994           Root MSE      =  .36064

------------------------------------------------------------------------------
     oil_per |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |  -.0106982   .0151057    -0.71   0.488    -.0425684     .021172
       _cons |   23.76945   30.25678     0.79   0.443    -40.06678    87.60568
------------------------------------------------------------------------------
```

Appendix B

Figure 3: Recovered Oil

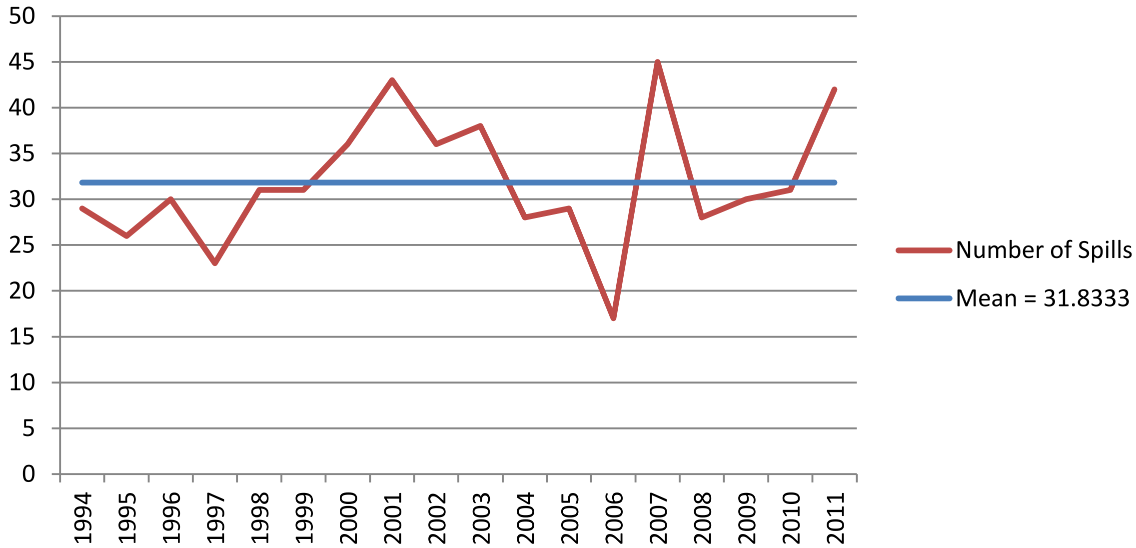



```
. reg recovered year, robust

Linear regression                                      Number of obs =      19
                                                       F(  1,    17) =    2.58
                                                       Prob > F      =  0.1264
                                                       R-squared     =  0.2591
                                                       Root MSE      =  341.48
```

recovered	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
year	-34.87702	21.69875	-1.61	0.126	-80.65737	10.90334
_cons	70089.85	43521.02	1.61	0.126	-21731.47	161911.2

Appendix C

Figure 4: Number of Spills




```
. reg spills year

      Source |       SS       df       MS              Number of obs =      19
-------------+------------------------------           F(  1,    17) =    0.16
       Model |  14.5280702     1  14.5280702           Prob > F      =  0.6927
    Residual |  1528.10351    17  89.8884417           R-squared     =  0.0094
-------------+------------------------------           Adj R-squared = -0.0489
       Total |  1542.63158    18  85.7017544           Root MSE      =   9.481

------------------------------------------------------------------------------
      spills |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |  -.1596491   .3971134    -0.40   0.693    -.9974851    .6781868
       _cons |   350.1982    795.421     0.44   0.665    -1327.993     2028.39
------------------------------------------------------------------------------

. reg spills year, robust

Linear regression                                      Number of obs =      19
                                                       F(  1,    17) =    0.11
                                                       Prob > F      =  0.7469
                                                       R-squared     =  0.0094
                                                       Root MSE      =   9.481

------------------------------------------------------------------------------
             |               Robust
      spills |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |  -.1596491   .4867047    -0.33   0.747    -1.186506    .8672081
       _cons |   350.1982   973.4309     0.36   0.723    -1703.561    2403.958
------------------------------------------------------------------------------
```

Appendix D

Figure 5: Location Ratios

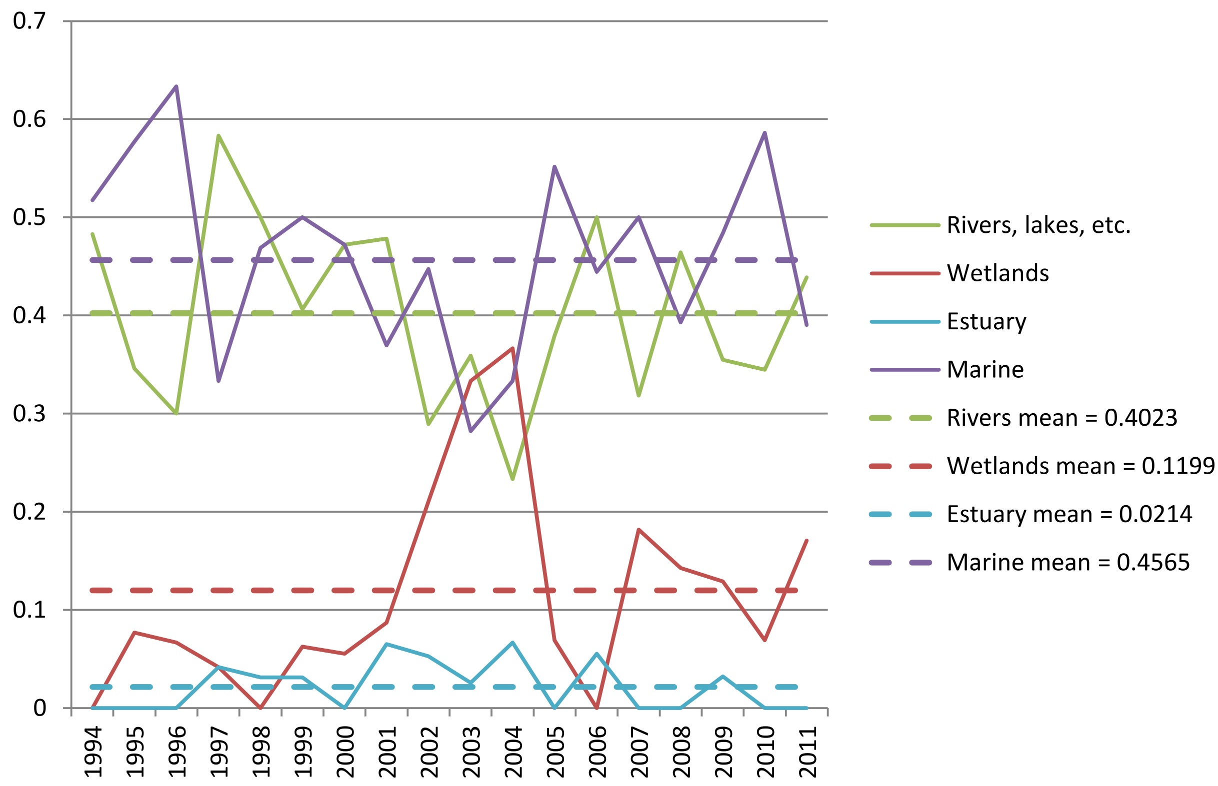
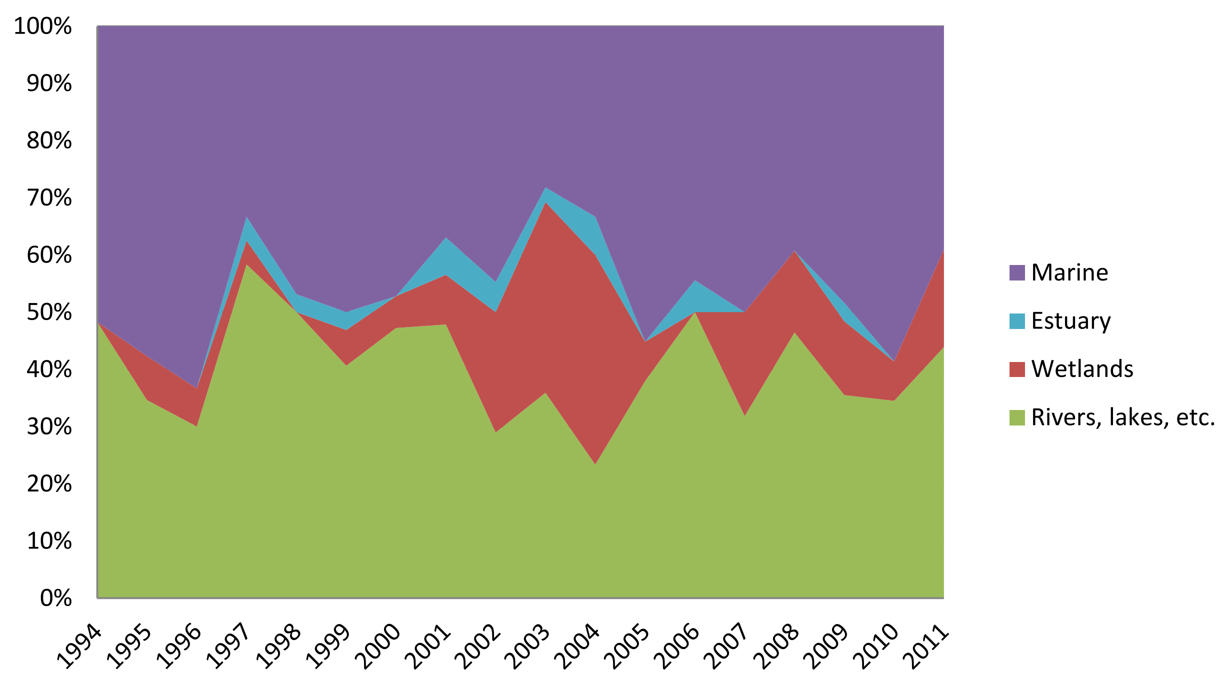


Figure 6: Stacked Location Ratios

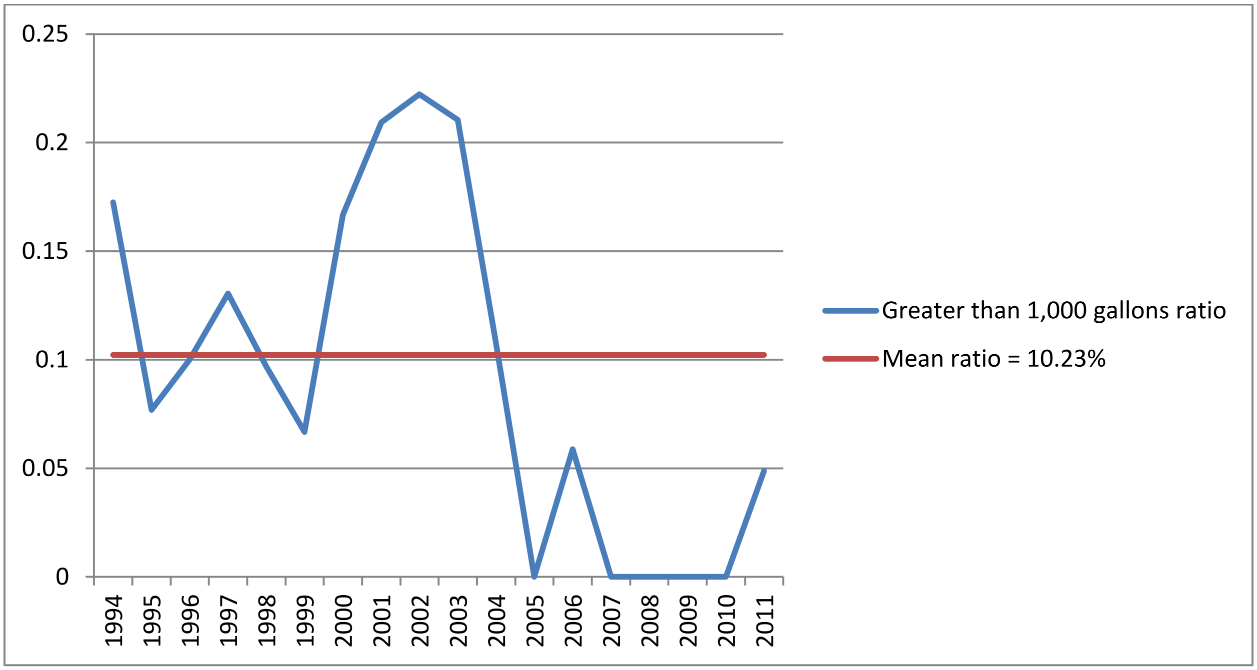


```
. reg freshratio year

      Source |       SS       df       MS              Number of obs =      18
-------------+------------------------------           F(  1,    16) =    0.72
       Model |  .006212881     1  .006212881           Prob > F      =  0.4084
    Residual |  .137919007    16  .008619938           R-squared     =  0.0431
-------------+------------------------------           Adj R-squared = -0.0167
       Total |  .144131888    17  .008478346           Root MSE      =  .09284

------------------------------------------------------------------------------
  freshratio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |   -.003581    .004218    -0.85   0.408    -.0125227    .0053608
       _cons |   7.573721   8.446546     0.90   0.383    -10.33216     25.4796
------------------------------------------------------------------------------

.
. reg wetratio year

      Source |       SS       df       MS              Number of obs =      18
-------------+------------------------------           F(  1,    16) =    2.42
       Model |  .024814807     1  .024814807           Prob > F      =  0.1393
    Residual |  .164010473    16  .010250655           R-squared     =  0.1314
-------------+------------------------------           Adj R-squared =  0.0771
       Total |   .18882528    17  .011107369           Root MSE      =  .10125

------------------------------------------------------------------------------
    wetratio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |   .0071566   .0045997     1.56   0.139    -.0025943    .0169075
       _cons |  -14.21653   9.210917    -1.54   0.142     -33.7428    5.309741
------------------------------------------------------------------------------

.
. reg estratio year

      Source |       SS       df       MS              Number of obs =      18
-------------+------------------------------           F(  1,    16) =    0.02
       Model |  .000015395     1  .000015395           Prob > F      =  0.8826
    Residual |  .010942023    16  .000683876           R-squared     =  0.0014
-------------+------------------------------           Adj R-squared = -0.0610
       Total |  .010957419    17  .000644554           Root MSE      =  .02615

------------------------------------------------------------------------------
    estratio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |  -.0001783   .0011881    -0.15   0.883    -.0026969    .0023403
       _cons |   .3793033   2.379118     0.16   0.875    -4.664201    5.422807
------------------------------------------------------------------------------
```

```
. reg marineratio year

      Source |       SS       df       MS              Number of obs =      18
-------------+------------------------------           F(  1,    16) =    0.59
       Model |  .005592291     1  .005592291           Prob > F      =  0.4533
    Residual |  .151445016    16  .009465314           R-squared     =  0.0356
-------------+------------------------------           Adj R-squared = -0.0247
       Total |  .157037307    17  .009237489           Root MSE      =  .09729

------------------------------------------------------------------------------
 marineratio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |  -.0033974     .00442    -0.77   0.453    -.0127674    .0059725
       _cons |   7.263507   8.851046     0.82   0.424    -11.49987    26.02689
------------------------------------------------------------------------------
```

Appendix E

Figure 7: Greater Than 1,000 Gallons Ratios




```
. reg ratio year

      Source |       SS       df       MS              Number of obs =      21
-------------+------------------------------           F(  1,    19) =    0.34
       Model |  .006498645     1  .006498645           Prob > F      =  0.5640
    Residual |  .358146415    19  .018849811           R-squared     =  0.0178
-------------+------------------------------           Adj R-squared = -0.0339
       Total |   .36464506    20  .018232253           Root MSE      =  .13729

------------------------------------------------------------------------------
       ratio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |   .0029051   .0049478     0.59   0.564    -.0074506    .0132609
       _cons |  -5.705163    9.90545    -0.58   0.571    -26.43751    15.02718
------------------------------------------------------------------------------
```

Appendix F

Table 17: Oil Type

Oil Type	Freq.	Percent	Cum.
ANS Crude	1	0.22	0.22
ANS crude	2	0.44	0.66
Ashphlt product	1	0.22	0.88
Asphalt product	1	0.22	1.11
Bunker	4	0.88	1.99
Bunker C	1	0.22	2.21
Bunker-C	3	0.66	2.88
Cooking Oil	2	0.44	3.32
Crude	2	0.44	3.76
Diesel	281	62.17	65.93
Diesel & Hydr oil	2	0.44	66.37
Diesel & Lube oil	1	0.22	66.59
Diesel & gasoline	3	0.66	67.26
Diesel & lube	1	0.22	67.48
Diesel and gas	1	0.22	67.7
Diesel, lube oil	1	0.22	67.92
Diesel/ Gasoline	1	0.22	68.14
Diesel/ Hydr oil	1	0.22	68.36
Diesel/ Lube	3	0.66	69.03
Diesel/ Lube oil	2	0.44	69.47
Diesel/ lube oil	3	0.66	70.13
Diesel; lube oil	2	0.44	70.58
Fish Oil	1	0.22	70.8
Fuel oil	1	0.22	71.02
Gas	1	0.22	71.24
Gasoline	27	5.97	77.21
Gasoline & Diesel	1	0.22	77.43
Gasoline & diesel	1	0.22	77.65
Heating Oil	1	0.22	77.88
Heating oil	3	0.66	78.54
Heating oil/diesel	1	0.22	78.76
Hyd Oil	1	0.22	78.98
Hyd oil	3	0.66	79.65
Hyd. oil	1	0.22	79.87
Hydr Oil	7	1.55	81.42
Hydr oil	21	4.65	86.06
Hydr oil, diesel	1	0.22	86.28
Hydr. Oil	1	0.22	86.5
Hydr. oil	3	0.66	87.17
Hydrr oil	1	0.22	87.39

IFO 180 (Bunker)	1	0.22	87.61
IFO 380	1	0.22	87.83
IFO-380	1	0.22	88.05
JP-5	3	0.66	88.72
JP-5 jet fuel	3	0.66	89.38
Jet Fuel	2	0.44	89.82
Jet fuel	1	0.22	90.04
Jet-A	1	0.22	90.27
Kerosene	2	0.44	90.71
Lube	1	0.22	90.93
Lube Oil	2	0.44	91.37
Lube oil	8	1.77	93.14
Lube/ bunker	1	0.22	93.36
MDO	1	0.22	93.58
Mineral oil	1	0.22	93.81
Petrol. distillate	1	0.22	94.03
Road sealant	1	0.22	94.25
Trans oil	1	0.22	94.47
Transf oil	1	0.22	94.69
Transf. oil	3	0.66	95.35
Turbine Oil	1	0.22	95.58
Turbine oil	4	0.88	96.46
Used lube and diesel	1	0.22	96.68
Used lube oil	2	0.44	97.12
Veg oil	1	0.22	97.35
Waste Lubes	1	0.22	97.57
Waste Oil	1	0.22	97.79
Waste lube oil	1	0.22	98.01
Waste oil	8	1.77	99.78
bunker-C	1	0.22	100
Total	452	100	